DIRECTED ENERGY WEAPONS

and

ACTIVE PROTECTION SYSTEMS

John E Anderson
Director, Eye Mirror, LLC

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Abstract	
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1. Principle of operation

Geometric optics:-

Paraboloid mirror focuses point source

Pair of surfaces direct area or volume source

Not diffraction limited !

2. Single stage

Defining mirror chosen (typically spherical)

Defining rays chosen (collimated, focussed or whatever)

Defined mirror's shape is a solution to a differential equation

Further rays partially directed

Angular input aperture allows area or volume source

Out-of-plane rays

Reflective and/or refractive surfaces

3. Multiple stages in series

Stage multiplication $\propto$ 1 / angular input aperture squared

$$\tan \beta_3 = - \tan(\theta_2 - \theta_1) \tan 0.75 (\theta_2 - \theta_1) \tan 0.5 (\theta_2 + \theta_1)$$

θ_1	145	142.2	100.000
θ_2	160	140.0	100.034
β	23	8	0
$0.5(\theta_2 + \theta_1) - \beta$	129.5	133.1	100.017
$2\theta_2 - 2\theta_1$	30	4.4	0.068
β_3	3.699	0.0678	8.57×10^{-5}
$\tan \beta_3$			1.49×10^{-6}

4. Beam adjustment and rotation

Moveable 3rd stage defined mirror

Axial movement focuses beam

Transverse movement corrects atmospheric distortion

40ms search to find target

High agility

5. Main advantages

Blackbody radiation - 1.5 MW_e arc lamps
(spatially but not temporally coherent)

Power increases as wavelength decreases (0.2 - 1.4 μm)

Wein's displacement law :- $\lambda_m T$ = constant

Stefan - Boltzmann law :- $P_{tot} = \sigma T^4$

Wide waveband - No Stimulated Raman Scattering

No lenses, lasing medium or inhomogeneities to distort beam

Power $\propto$ mirror size $\propto$ cooling

6. Dynamic kill on a continuous basis

Optimum range cusp

Effects of lower wavelengths:-

- Smaller spots
- Higher power
- Poor reflectivity
- Reduced dynamic kill threshold
- More absorption and scattering

7. Typical applications

Combat aircraft	- 0.6m turret	$3.5MW_e$ / $1.4MW_{opt}$
	- 0.5m pod	$3.5MW_e$ / $1.4MW_{opt}$
	- 0.5m pod with APU &HPG	$15MW_e$ / $6MW_{opt}$
Transport aircraft	- 0.6m turret	$3.5MW_e$ / $1.4MW_{opt}$
Future Combat System	- 0.75m flush turret	$15MW_e$ / $6MW_{opt}$
Airborne DEW	- 3.6m turret	$200MW_e$ / $80MW_{opt}$
Space based DEW	- 2m diamond turning	$240MW_e$ / $100MW_{opt}$
	- 4.5m diamond turning	$1000MW_e$ / $400MW_{opt}$

8. Active protection

All types of platform

All types of target

Rate of fire exceeds all but LAA - typical 200ms engagement

Protection of accompanying forces:- APCs, dismounted infantry

Relation to countermeasures & jamming

9. Combat aircraft

BASIC 1600 lbs

3.5 MW_e iron rotor homopolar generator

Two 24in diameter DEW turrets

4 UV+ fire control sensor turrets

12 MWIR sensors

OPTIONAL

24in diameter pod for longer range DEWs

ALTERNATIVE POWER SUPPLY

136 kW APU + 11 MJ IED HPG

10. Number of Targets Engaged

1st DEW		$n((R-r)/v+0.1)$
2nd DEW		$n(R-r)/v$
n	pulses/sec	5 for missiles 3.3 for hittiles
R	metres	effective range
r	metres	minimum range
v	metres/sec	relative velocity

Turret

IRGMs head - on	1st DEW	2nd DEW
Clear at sea level	6	5
Median haze at sea level	2	2

Pod

Head - on	1st DEW	2nd DEW
Clear/Radar guided missiles	11	11
Median Haze/Beam-riding hittiles	3	2

11. All Types of Target

IRGMs

Active, semi-active and passive radar guided missiles

Beam-riding or command guidance hittiles

Aircraft

HAA

LAA (All shells or selected)

KE long-rod penetrators

12. Relation to Countermeasures

DEW as jammer at very long range

Counter to imaging IR seekers distinguishing flares

Vulnerability of launch operation in beam-riding system

No point in weight penalty for stealth

ARMs vulnerable to DEWs using comercial sources

Shoulder fired DEWs with chemical rounds

13. Radar Jaming

Invulnerable stand forward jamming platform

3.5 MW_e available

Barrage jamming over a wider waveband counters LPI

Room for high power jammers in same pod

“Moving” chaff by illumination

Escorting cruise missiles using DEWs and jammers